Rehabilitation Psychology
2009, Vol. 54, No. 3, 270–278

DOI: 10.1037/a0016736

Postconcussive Symptoms in OEF–OIF Veterans: Factor Structure and Impact of Posttraumatic Stress

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Purpose: Veterans with a history of mild traumatic brain injury (mTBI) are reporting postconcussive symptoms (PCSx) in addition to experiencing postdeployment physical and emotional comorbidities. The Veterans Health Administration has mandated specialized evaluation and treatment for veterans with a history of mTBI and has suggested widespread use of the Neurobehavioral Symptom Inventory (NSI) as a measure of PCSx. This study evaluated the NSI's factor structure and assessed the impact of posttraumatic stress (PTS) on the scale at the item and factor levels. ***Research Method:*** Five hundred twenty-nine charts of returning veterans who screened positive for traumatic brain injury were reviewed, and 345 who met criteria for mTBI were included in the study. ***Results:*** Results of factor analysis on the NSI revealed a difficult-to-interpret factor structure that was inconsistent with the results of civilian studies. PTS explained 5%–38% of the variance in individual PCSx, and after controlling for this variance, the factor structure more closely paralleled findings from the civilian literature. ***Conclusion:*** PTS is an important variable to account for when evaluating PCSx in veterans. Research and clinical implications for the measurement and interpretation of self-reported PCSx are discussed.

Keywords: factor analysis, measurement, mild traumatic brain injury, postconcussive symptoms, posttraumatic stress, veterans

Traumatic brain injury (TBI) has been described as the "signature wound" of Operations Enduring Freedom and Iraqi Freedom (OEF–OIF; Hayward, 2008). An estimated 300,000 service members returning from OEF–OIF may have a history of mild traumatic brain injury (mTBI; Tanielian & Jaycox, 2008), as operationalized by the presence of at least one of these symptoms after experiencing an external force to the head: loss of consciousness of 30 min or less, loss of memory (posttraumatic amnesia) of less than 24 hr, or feeling dazed or confused for less than 24 hr after the injury (Defense and Veterans Brain Injury Center, 2006). A mTBI can produce a host of cognitive, affective, and physical sequelae in the first few days to weeks after injury, with the vast majority of studies of civilian mTBI indicating a return to average neuropsychological functioning within 1 to 3 months after injury (Alexander, 1995; Belanger & Vanderploeg, 2005). A subset of individuals, however, report a persistent constellation of symptoms marked by cognitive, emotional, and physical complaints for many months to years after injury. These symptoms are collectively known as postconcussive symptoms (PCSx), and recent evidence has suggested that 38.9% of recent veterans with a history of mTBI reported at least one PCSx within 1 year after injury (Terrio et al., 2009).

The lack of specificity of PCSx, however, presents a significant diagnostic challenge when attempting to establish a causal link between a history of mTBI and current PCSx. For example, Iverson and Lange (2003) found that healthy, nonconcussed individuals endorsed individual PCSx at a rate of 35.9% to 75.7%, depending on the symptom. PCSx are also frequently endorsed in orthopedic-injured (i.e., non–brain-injured) individuals. To this point, 47% of individuals with an orthopedic injury endorsed at least three PCSx 1 year after injury compared with 78% of individuals with a history of mTBI (Mickeviciene et al., 2004). Furthermore, no differences were found between the total number of PCSx endorsed by individuals with chronic pain or history of mTBI, and the overall pattern of their symptom endorsement overlapped to a significant degree (Smith-Seemiller, Fow, Kant, & Franzen, 2003). Individuals with mental health problems also frequently report PCSx. For example, in summarizing the base rates of PCSx in 400 individuals referred for psychotherapy, Fox, Lees-Haley, Earnest, and Dolezal-Wood (1995) concluded that the occurrence of "many of these self-reported symptoms was so high among those without [loss of consciousness] that such a complaint cannot be used to indicate the presence of a post-concussive condition with any precision" (p. 91).

The impact of comorbidities on PCSx endorsement is of critical importance when evaluating veterans' self-reports because they

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Parts of this work were presented as a poster at the 37th annual meeting of the International Neuropsychological Society, Atlanta, GA.

This material is based on work supported by the Office of Academic Affiliations, U.S. Department of Veterans Affairs.

We thank the veterans who participated in this study and the Polytrauma Network Site Teams at the Michael E. DeBakey Veterans Affairs Medical Center and the George E. Wahlen Veterans Affairs Medical Center for the assistance with data collection and database management.

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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
2009		**00-00-2009 to 00-00-2009**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Postconcussive Symptoms in OEF-OIF Veterans: Factor Structure and Impact of Posttraumatic Stress	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Michael E. DeBakey VA Medical Center ,2002 Holcombe Boulevard,Houston,TX,77030**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**9**	

may have experienced other physical injuries while in the service, may be coping with postdeployment mental health issues, or both. In terms of mental health problems, 19.1% of veterans returning from Iraq and 11.3% of veterans returning from Afghanistan screened positive for at least one mental health problem (Hoge, Auchterlonie, & Milliken, 2006). However, in veterans with a history of mTBI, the rates of some disorders such as posttraumatic stress disorder (PTSD; 43.9%) are dramatically higher than those in other injured (16.2%) or noninjured cohorts (9.1%; Hoge et al., 2008). Also noted in this study was that the level of combat intensity reported by individuals with a history of mTBI was much higher than that reported by individuals without such a history. Thus, in clinical practice, the evaluation of individuals with a history of mTBI also likely selects for those with higher rates of trauma exposure and subsequent psychiatric distress.

In addition to mental health comorbidities, returning veterans frequently report other injuries that can obfuscate the interpretation of PCSx. For example, veterans with a history of TBI often experience concomitant musculoskeletal injuries, which frequently result in chronic pain (Clark, Bair, Buckenmaier, Gironda, & Walker, 2007). Chronic pain is, in turn, associated with increased emotional distress and cognitive disturbances in addition to somatic complaints, all of which are cardinal PCSx (Iverson & McCracken, 1997). Other common physical conditions in veterans with a history of mTBI may also complicate interpretation of PCSx. For example, the prevalence of blast injury in veterans with mTBI may predispose them to inner ear injuries because the tympanic membranes and middle-ear structures are exquisitely sensitive to the rapid pressure changes that accompany a blast (Centers for Disease Control and Prevention, 2008). Although such injuries are more common in individuals reporting a loss of consciousness after a blast (Xydakis, Bebarta, Harrison, Conner, & Grant, 2007), the long-term sequelae of such injuries (i.e., balance problems or dizziness) may reflect more residual inner ear dysfunction than long-term sequelae from brain injury in at least some individuals.

In recognition of the complex interplay of neurological, psychological, and physical factors in veterans returning with mTBI, current Veterans Health Administration guidelines call for specialized evaluation and management of veterans with a history of mTBI (U.S. Government Accountability Office, 2008, p. 26). As a part of this screening and evaluation process, returning veterans with a suspected history of mTBI complete the Neurobehavioral Symptom Inventory (NSI; Cicerone & Kalmar, 1995). The NSI is a 22-item self-report measure that asks individuals to rate their difficulties with a variety of symptoms. The 22 items were derived from a larger structured clinical interview originally created by Levin et al. (1987) to capture common complaints after mTBI. Although it is widely used within the Veterans Affairs (VA) system, relatively little is known about its psychometric properties. In particular, no studies to date have evaluated the NSI's factor structure or how common comorbidities in veteran populations, such as posttraumatic stress (PTS), could influence its factor structure.

In their initial publication on the NSI, Cicerone and Kalmar (1995) performed a cluster analysis on a rather select group of 50 clinical referrals (all of whom were involved in litigation) with a history of mTBI. Results of this analysis suggested that PCSx fell into affective, cognitive, somatic, and sensory clusters. Headaches, sleep problems, and numbness did not load well onto any one cluster. However, results of this work must be interpreted cautiously, given the unrepresentative nature of the small sample. Furthermore, the cluster analysis methodology used in this study is susceptible to early spurious relationships affecting later observed results, and this form of analysis is unable to account for more complex relations between variables. In addition, there have been no replications of this study in other samples.

Despite these limitations, more recent factor analytic studies of other PCSx questionnaires have generally supported a two- to five-factor solution, with at least partially distinct cognitive, affective, and somatic factors (Axelrod et al., 1996; Ayr, Yeates, Taylor, & Browne, 2009; Eyres, Carey, Gilworth, Neumann, & Tennant, 2005; Piland, Motl, Ferrara, & Peterson, 2003). However, many of these studies have also found a number of items that did not load well onto factors. For example, Rasch modeling of the Rivermead Post-Concussion Questionnaire revealed that dizziness, nausea, and headaches did reflect the same underlying construct as other PCSx and formed a separate subscale (Eyres et al., 2005). Piland et al. (2003) found that sensory sensitivity, tingling, difficulty remembering, and emotional problems did not fit into an otherwise prototypical three-factor profile in a sample of concussed athletes. Despite such variability at the individual item level, three factors (i.e., Cognitive, Affective, and Somatic) are viewed as underlaying the so-called postconcussive syndrome.

In this study, we sought to further our understanding of self-reported PCSx on the NSI in returning veterans with a history of mTBI by elucidating what factors underlay this instrument. In addition, we sought to evaluate how PTS affects the scale at both the item and factor levels.

Method

Participants

For the current study, we reviewed the records of 529 veterans who were evaluated by the polytrauma team (a multidisciplinary team consisting of a physiatrist, nurse practitioner, neuropsychologist, speech–language pathologist, social worker, and physical and occupational therapists) at a southern ($n = 361$) and a northwestern ($n = 168$) VA hospital. Chart review was approved by the institutional review boards of both facilities. We selected veterans if they had a self-reported history of mTBI as evidenced by identifying a mechanism of injury and endorsing at least one of the following symptoms: a loss of consciousness of less than 30 min, posttraumatic amnesia for less than 24 hr, or feeling dazed for less than 24 hr after the injury (Defense and Veterans Brain Injury Center, 2006). We excluded 98 records from this evaluation on the basis of not reporting at least one of the criteria and thus not likely having suffered a definable brain injury. We excluded an additional 69 records because the veteran endorsed at least one injury severity characteristic indicative of a moderate to severe brain injury (e.g., a loss of consciousness of longer than 30 min). In addition, we excluded 17 records because the veteran reported that an object had penetrated the skull, suggesting at a minimum a complicated mTBI (Williams, Levin, & Eisenberg, 1990). In total, 345 records were included in the current analysis. Demographics, military service, and injury characteristics are found in Table 1.

Table 1
Demographic Characteristics of the Sample (N = 345)

Characteristic	%	*M*	*SD*
Gender (% male)	96.2		
Age		30.4	7.5
Ethnicity			
African American	11.6		
White	66.4		
Hispanic	18.6		
Other	3.5		
Education			
High school diploma or equivalent	55.9		
Some college	37.1		
College graduate	5.8		
Other	1.2		
Branch of service			
Air Force	4.3		
Army	50.4		
Marine	24.3		
National Guard	13.3		
Navy	6.7		
Time since last deployment (months)		27.3	18.9
Injury characteristics			
Loss of consciousness	39.4		
Disorientation	95.9		
Posttraumatic amnesia	34.2		
Report at least 1 blast injury	64.6		
Report at least 1 motor vehicle accident	29.9		
Report at least 1 fall	25.5		
Time since most recent injury (years)[a]		3.0	1.6
Clinical characteristics			
PCL total score		53.5	15.6
PCL total ≥50	55.7		

Note. PCL = Post-Traumatic Stress Disorder Checklist, Civilian Version.
[a] Time since most recent injury information was only available on 236 participants. Total of percentages may not equal 100% because of rounding.

Procedure

OEF–OIF veterans were administered a 4-item TBI screen (Belanger, Uomoto, & Vanderploeg, 2009) on initiating services at the VA hospital. Individuals who screened positive for a past history of mTBI (Items 1–3 of the screen) in addition to having current functional difficulties (Item 4 of the screen) were referred for an evaluation by a specialty provider or team. As a part of this evaluation, veterans completed various self-report measures, including the NSI (described in the introduction); the PTSD Checklist, Civilian Version (PCL-C); and an injury severity self-report questionnaire. The PCL-C is a 17-item screen developed to mirror the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., or *DSM–IV*; American Psychiatric Association, 1994) criteria for PTSD (Weathers, Litz, Herman, Huska, & Keane, 1993). We used the civilian version of the PCL rather than the military version because the wording of the military version specifies that the traumatic event happened in the service, whereas the PCL-C's wording allows for the possibility (but not the exclusion) of nonmilitary events to be related to traumatic stress. Each item from the three symptom clusters as described in the *DSM–IV* is rated on a scale of frequency ranging from 1 (*rarely*) to 5 (*extremely*). Individuals who have scores higher than 50 on this instrument are likely to meet criteria for PTSD; however, in this study we were interested in the full range of PTS symptoms, including subthreshold PTSD. Thus, we used PCL-C scores as a continuous variable and a marker of PTS. Descriptors from the PCL-C and of the individuals exceeding the cutoff for PTSD are presented in Table 1. The injury severity questionnaire asked veterans to describe information relevant for each possible brain injury. Such information included the number of injuries, the type of injuries (blast, motor vehicle accident, fall, gunshot wound, etc.), length of loss of consciousness, length of confusion, length of any posttraumatic amnesia, and other injuries suffered.

Data Analysis

We conducted a principal-components analysis using SPSS 16.0 (SPSS Inc., 2007). Exploratory factor analytic techniques such as the one used in this study use a correlation matrix to extract factors, and thus researchers must choose the appropriate correlation matrix on which to base subsequent analyses. The NSI data are ordinal rather than interval in nature, and thus we used Spearman's rho correlations as the source matrices for all factor analyses conducted in this study.

The number of factors retained for each analysis was based on a combination of parallel analysis, Guttmann's criteria, and evaluation of the scree plot (see Thompson, 2004, pp. 27–48, for a discussion of relevant factor analytic procedures and the decision-making sequence). Given the exploratory nature of the analyses, we used both orthogonal and oblique rotations in an effort to find simple structure in the results as defined by few cross-loadings of variables, an interpretable structure, and relatively high loadings of each item on a factor.

In the next stage of our analyses, we sought to evaluate how PTS, a common comorbidity in veterans with a history of mTBI, affected the NSI at both item and factor levels. To address item-level overlap, we regressed PCL-C total scores on individual NSI items. Then, to understand the factor structure of the residual variance (NSI item minus the variance shared with the PCL-C), we retained the unstandardized residuals of the regressions. We subsequently submitted these residuals to principal-components analysis again (using the factor analytic decision methods described earlier) to evaluate how statistically controlling for PCSx affected the underlying structure of the NSI.

Results

NSI Factor Structure

Spearman rho correlations between NSI full items are presented in Appendix A. Visual inspection of the correlation matrix, the Kaiser-Meyer-Olkin coefficient of .92, and Bartlett's test of sphericity ($\chi^2 = 3{,}508.0$, $p < .01$) suggested that the matrix could be factored, and thus the analyses proceeded. Principal-components analysis results suggested four components with eigenvalues greater than 1, explaining a total of 57.9% of the variance (38.4%, 8.6%, 6.2%, and 4.9% of the variance for each factor, respectively). Analysis of the scree plot was not clear, although a subtle break, or "elbow," was observed after the fourth factor. Because the values for these factors exceeded those generated from a randomly created database of the same specifications (parallel analysis), we retained these four factors for rotation.

We performed both varimax and promax rotations on this solution to aid in interpretation. Unfortunately, neither solution yielded a simple structure. The varimax rotation is presented in Table 2 and is representative of the interpretation difficulties resulting from this analysis. Dizziness, loss of balance, poor coordination, sensitivity to light, slowed thinking, and fatigue strongly cross-loaded (factor loadings greater than .4 on more than one factor). In addition, the factor solution was marked by a first factor that was difficult to interpret because it was composed of myriad sensory, cognitive, and motoric symptoms. The second factor was marked by items pertaining to emotional disturbance, a third factor seemed to suggest a headache factor (marked by headaches and nausea), and sensory disturbances were noted on the fourth factor. Oblique rotation of the results did not appreciably improve interpretation because pattern coefficients (roughly equivalent to beta weights in regression analyses) showed relatively fewer cross-loadings, but structure coefficients (correlations of items with the various factors) showed that nearly every item strongly correlated with more than one factor.

NSI Factor Structure After Controlling for PTS

To evaluate how PTS might be affecting the factor structure of this instrument, we explored the relationship of the PCL-C total to each NSI item. Using simple regression, we regressed the PCL-C total score onto each NSI symptom, with the amount of variance explained in each item ranging from 5.8% (vision problems) to 39.7% (feeling anxious; Table 3). Using the results from the initial factor analysis described earlier, items on Factor 2 (affective) predictably shared the most variance with PTS. Of the 11 items that loaded onto the first factor, 6 had at least 20% of their variance explained by PTS. To determine more specifically how PTS might affect the NSI factor structure, we retained residuals from these regression analyses and submitted them to factor analysis using the same strategies as the initial analysis outlined earlier.

Table 2
Summary of Factor Loadings for Varimax Four-Factor Solution for the Neurobehavioral Symptom Inventory

Variable	Varimax rotated pattern–structure coefficients			
	Factor 1	Factor 2	Factor 3	Factor 4
Feeling dizzy	**.57**	.07	**.55**	−.07
Loss of balance	**.56**	.04	**.55**	.08
Poor coordination	**.61**	.14	**.44**	.07
Headaches	.07	.24	**.71**	−.01
Nausea	.14	.24	**.68**	−.02
Vision problems	.30	−.04	**.52**	.32
Sensitivity to light	.00	.16	**.59**	**.47**
Hearing difficulty	.30	.04	−.05	**.64**
Sensitivity to noise	.03	.38	.18	**.68**
Numbness or tingling	**.54**	.12	.31	.09
Change in taste or smell	**.44**	.10	.30	.31
Loss of appetite	**.45**	.38	.35	.09
Poor concentration	**.61**	.49	.03	.21
Forgetfulness	**.64**	.36	.02	.24
Difficulty making decision	**.67**	.37	.07	.20
Slowed thinking	**.73**	**.40**	−.02	.09
Fatigue	**.54**	**.46**	.23	.02
Difficulty falling asleep or staying asleep	.13	**.57**	.36	.18
Feeling anxious	.21	**.73**	.15	.22
Feeling depressed or sad	.25	**.74**	.17	−.02
Irritability	.20	**.79**	.11	.12
Poor frustration tolerance	.26	**.80**	.09	.06

Note. Boldface type indicates factor loadings ≥.40.

Table 3
Descriptives for Neurobehavioral Symptom Inventory Items and Results of Regression (Posttraumatic Stress Disorder Checklist, Civilian Version, Onto Neurobehavioral Symptom Inventory Items)

Variable	*M*	*SD*	R^2
Feeling dizzy	1.47	0.86	.12
Loss of balance	1.32	0.92	.10
Poor coordination	1.32	0.93	.13
Headaches	2.29	1.04	.08
Nausea	1.13	1.01	.11
Vision problems	1.51	1.07	.06
Sensitivity to light	1.72	1.17	.08
Hearing difficulty	1.88	1.06	.06
Sensitivity to noise	1.85	1.11	.22
Numbness or tingling	1.61	1.19	.11
Change in taste or smell	0.82	1.03	.14
Loss of appetite	1.53	1.13	.26
Poor concentration	2.31	1.08	.28
Forgetfulness	2.50	1.04	.22
Difficulty making decision	1.72	1.12	.24
Slowed thinking	1.96	1.18	.23
Fatigue	2.10	1.11	.22
Difficulty falling asleep or staying asleep	2.72	1.17	.34
Feeling anxious	2.58	1.08	.40
Feeling depressed or sad	2.09	1.20	.43
Irritability	2.76	1.06	.36
Poor frustration tolerance	2.41	1.17	.34

Note. All $ps < .01$.

Spearman rho correlations between NSI residuals are presented in Appendix B. Again, visual inspection of the correlation matrix, the Kaiser-Meyer-Olkin coefficient of .83, and Bartlett's test of sphericity ($\chi^2 = 1{,}936.0$, $p < .01$) suggested that the matrix could be factored. Principal-components analysis results revealed six components with eigenvalues greater than 1, explaining a total of 57.0% of the variance (24.6%, 9.1%, 7.4%, 5.7%, 5.3%, and 4.9 % of the variance, respectively, for each component). Scree plot analysis was again unclear, with breaks present at 4, 6, and 10 factors. Because the values for a six-factor solution exceeded those generated from parallel analysis, added a significant amount of the variance to the analysis, and were easily interpretable, we retained these factors. Varimax rotation of the six factors yielded a relatively simple structure (Table 4), and the results paralleled that of an oblique (promax) rotated structure presented in Table 5. Factor 1 was marked by difficulties with concentration and slowed thinking and was thus labeled a cognitive factor. Factor 2 was marked by loss of balance and dizziness and was thus termed a vestibular disturbance factor. Frustration, depression, and irritability marked a third, mood disturbance factor. Factor 4's strongest loading variable was change in taste or smell. Other strong loadings on this factor (loss of appetite, numbness or tingling) suggested that it was marked by sensory complaints, although difficulty falling asleep also loaded

Table 4
Summary of Factor Loadings for Varimax Six-Factor Solution for the Neurobehavioral Symptom Inventory Residuals After Controlling for Posttraumatic Stress

Variable	Varimax-rotated pattern–structure coefficients					
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Feeling dizzy	.23	**.73**	.03	.17	.04	−.05
Loss of balance	.20	**.74**	.05	.20	.06	.10
Poor coordination	.29	**.66**	.13	.23	.01	.08
Headaches	.11	**.44**	.02	−.11	**.68**	−.12
Nausea	−.03	**.57**	.09	.03	**.40**	.00
Vision problems	.10	**.46**	−.03	.23	.20	.29
Sensitivity to light	.03	.19	−.08	.20	**.66**	.27
Hearing difficulty	.15	.20	.10	−.03	−.20	**.66**
Sensitivity to noise	.05	−.07	.03	.11	.32	**.71**
Numbness or tingling	.22	.28	.05	**.60**	−.03	.00
Change in taste or smell	.11	.14	−.11	**.72**	.02	.24
Loss of appetite	.24	.26	.10	**.51**	.10	−.18
Poor concentration	**.79**	.10	.12	.05	.13	.07
Forgetfulness	**.71**	.21	.07	.03	−.01	.10
Difficulty making decision	**.71**	.14	.02	.21	.05	.13
Slowed thinking	**.76**	.20	.10	.13	−.10	.02
Fatigue	**.49**	.10	.22	.39	.18	−.15
Difficulty falling asleep or staying asleep	−.09	.02	.20	**.45**	.38	−.13
Feeling anxious	.37	−.22	.38	.09	**.44**	.03
Feeling depressed or sad	.02	.07	**.65**	.27	−.02	−.15
Irritability	.09	.07	**.80**	−.06	.02	.16
Poor frustration tolerance	.24	.09	**.80**	−.05	.06	.09

Note. Boldface type indicates factor loadings ≥.40.

strongly onto this factor. Headaches and light sensitivity were the highest loadings on Factor 5, which suggested a headache factor. However, anxiety also loaded strongly onto this factor, which was not expected or easily interpretable. Hearing problems (difficulty with hearing and sensitivity to noise) made up the final factor. Only two items cross-loaded significantly, with headaches loading onto both the headache factor and the vestibular factor. Similarly, nausea was a part of both the headache and the vestibular factors.

Discussion

In this study, we sought to evaluate the NSI's factor structure in a sample of returning veterans with a history of mTBI. Results revealed that without accounting for PTS, the NSI's factor structure did not parallel studies from the civilian literature suggesting that PCSx instruments measure three core factors (i.e., cognitive, affective, and sensory). In our study, some items, such as somatic concerns and cognitive problems, seemed to cluster together in a way that was inconsistent with the civilian literature. To determine whether PTSD symptoms may be at least partially responsible for these unusual findings, we regressed PCL-C scores on each NSI item. Responses revealed that there was significant overlap between PTS and somatic symptoms from the NSI. After removing this shared variance, the NSI's factor structure more closely resembled that found in civilian studies, with the first three factors roughly paralleling the more traditional cognitive, affective, and somatic structure, although the somatic items appeared to fractionate into vestibular, headache, and sensory factors. This study provides insight into the construct of PCSx in combat veterans, highlights the need for consideration of comorbidities in research on mTBI and PCSx, and emphasizes the importance of an interdisciplinary approach in the assessment and treatment of combat veterans with a history of mTBI.

Factors of PCSx

In the civilian literature, emotional distress is known to complicate recovery from mTBI and to contribute to the development of PCSx (Iverson, 2005). In this study, PTS shared a statistically significant amount of variance with every PCSx. Although one might expect that some symptoms, such as anxiety and concentration difficulties (hallmarks of PTSD), would necessarily have overlap between the conditions, as much as 5%–13% of the variance in somatic and sensory symptoms was shared with PTS as well. The result of this overlap was a first factor that explained a significant amount of the variance in PCSx report yet was not readily interpretable.

Statistically controlling for PTS allowed cognitive, vestibular, and sensory items (components of the first factor) to separate into different factors, whereas the remainder of the factor structure remained stable. Thus, from a statistical standpoint, not controlling for PTS served to bind several cognitive, vestibular, and sensory items together. After controlling for PTS, these factors still existed but explained independent parts of the total variance. The first three factors that emerged roughly mirrored the factor structures found in civilian samples, which generally include somatic, affective, and cognitive factors, in addition to other factors (see Potter, Leigh, Wade, & Fleminger, 2006, p.1605, for a review). There was also evidence that somatic symptoms might fractionate in a way that is unique to a veteran polytrauma sample. For example, the second factor in the NSI residual analysis (after controlling for PTS) was marked by dizziness and balance problems. In the

Table 5
Summary of Factor Loadings for Promax Six-Factor Solution for the Neurobehavioral Symptom Inventory Residuals After Controlling for Posttraumatic Stress

Variable	Varimax-rotated pattern–structure coefficients					
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Feeling dizzy	.10	**.73**	−.00	.06	.05	−.10
Loss of balance	.04	**.72**	.04	.11	.06	.05
Poor coordination	.14	**.62**	.10	.14	−.01	.03
Headaches	.06	**.41**	−.07	−.26	**.74**	−.15
Nausea	−.16	**.58**	.07	−.08	**.43**	−.03
Vision problems	−.03	**.41**	−.05	.17	.21	.26
Sensitivity to light	−.05	.10	−.15	.13	**.69**	.25
Hearing difficulty	.07	.18	.17	−.05	−.21	**.66**
Sensitivity to noise	−.01	−.17	.03	.10	.32	**.71**
Numbness or tingling	.08	.19	.00	**.60**	−.10	−.04
Change in taste or smell	−.03	.03	−.15	**.78**	−.06	.20
Loss of appetite	.12	.16	.03	**.48**	.04	−.06
Poor concentration	**.84**	−.03	−.01	−.08	.10	.02
Forgetfulness	**.74**	.11	−.03	−.08	−.03	.06
Difficulty making decision	**.73**	.00	−.10	.12	.01	.08
Slowed thinking	**.78**	.09	−.01	.04	−.14	−.04
Fatigue	**.43**	−.02	.10	.32	.11	−.19
Difficulty falling asleep or staying asleep	−.22	−.05	.15	**.45**	.33	−.14
Feeling anxious	.36	−.34	.28	.02	**.40**	.02
Feeling depressed or sad	−.16	.05	**.68**	.25	−.11	−.14
Irritability	−.08	.06	**.86**	−.12	−.05	.19
Poor frustration tolerance	.09	.06	**.83**	−.13	−.01	.10

Note. Boldface type indicates factor loadings ≥.40.

context of a sample with significant blast exposure, these items could suggest a constellation of vestibular dysfunction, although this hypothesis warrants further exploration.

Research Implications

In terms of guiding future research, this study demonstrates that from a statistical standpoint, PTS and PCSx are not independent variables. Exploratory factor analyses attempt to derive latent variables underlying a measure of interest. In this study, PTS was not distinct from PCSx and indeed exerted a considerable influence on performance at both the item and the factor level. This finding clearly demonstrates the importance of controlling for comorbidities when attempting to evaluate PCSx because not accounting for these variables may serve to obfuscate clinical presentations and otherwise introduce unwanted heterogeneity into research trials. This point is especially true for cognitive and affective complaints in PCSx because PTS accounts for a great deal of variance in these variables.

This study also calls into question the grouping together of variables into cognitive, affective, and somatic clusters in veteran samples. First, from a statistical standpoint this practice is problematic unless other variables are controlled for. Cognitive and somatic symptoms seem to cluster more tightly with one another in veteran samples than to represent distinct symptom groupings. In addition, our results suggest that some items, such as dizziness, balance problems, nausea, and headaches, may covary together in a meaningful way that is unique to the veteran population (e.g., suggesting a headache or vestibular dysfunction scale). Future research may seek to analyze whether specific types of physical symptoms, such as vestibular or hearing difficulties, can serve as a more objective marker for mTBI or as a marker of a particular mechanism of polytraumatic injury such as blast injury.

Clinical Implications

Veterans returning from OEF–OIF often present with a history of probable mTBI and myriad symptoms and self-reported complaints. It is not uncommon for these veterans to have a number of conditions, including PTS or PTSD, other emotional disturbances, substance abuse, musculoskeletal issues, or chronic pain. This study demonstrates that a holistic view of the contributors to a individual's symptom reports is warranted. Interdisciplinary treatment teams, including mental health practitioners, psychologists, physiatrists, and the various therapists are crucial to the evaluation and treatment of any given individual's self-reported problems.

A second, but related point is the importance of recognizing the limitations of self-report questionnaires in the interpretation of a individual's clinical picture. For example, from both conceptual and statistical viewpoints, PCSx and PTS are not distinct entities. The finding of a history of alteration in consciousness and a current report of somatic, cognitive, and affective complaints is not sufficient to establish a causal link between PCSx and mTBI. The factors explaining such symptoms are myriad (the current study examined only PTS and not such factors as substance abuse, chronic pain, etc.). Veterans deserve a careful and thorough evaluation of self-reported symptoms in the context of their entire clinical picture. Furthermore, incorrectly attributing current PCSx to a history of brain injury could delay the implementation of effective treatment for associated conditions that are adversely affecting the individual's well-being.

Limitations

This study was limited by the self-report nature of the data. Although the National Center for Injury Prevention and Control (2003) issued a statement that supports the use of self-reported injury severity characteristics when other medical records are not available, the nature of combat makes interpretation of self-reported alterations in consciousness more difficult. For example, many individuals report dissociation in the middle of a traumatic event such as an ambush. This dissociation in the moment of trauma could be perceived as an alteration in consciousness, even if no sufficient force was exerted to cause an alteration in neurological functioning.

In addition, the subjective nature of cognitive and emotional complaints is difficult to interpret. For example, many studies have suggested that self-report of memory problems correlates poorly with performance on objective memory measures (see Mendes et al., 2008, for a review and discussion). Thus, our results cannot be interpreted as indicating, for example, that PTS explains memory problems in veterans with a history of mTBI. Rather, this study gives further evidence that the presence of PTS affects self-reported memory complaints and that these conditions are not unique from a measurement perspective.

Another limitation of this study is that other common comorbidities (such as pain, substance abuse, and other mental health problems) were not accounted for. Although PTS is prevalent in veterans with a history of mTBI (Hoge et al., 2008), it is one of many common conditions that may affect PCSx. Finally, our sample was seen on average nearly 2 years after deployment, suggesting that any mTBI would have occurred at an even more distant time. Thus, our results, although likely generalizable to samples currently engaging the VA health care system, are skewed in comparison to many civilian studies that evaluate people months rather than years after mTBI.

Conclusions

PCSx are complex phenomena that likely involve biological and psychological mechanisms that may be affected by a host of factors. This study highlights the potential impact of one common comorbidity, PTS, on PCSx in veterans with a history of mTBI. This study clearly demonstrates the need for careful statistical or methodological controls for PTS when evaluating PCSx and emphasizes the need for interdisciplinary assessment and treatment of returning veterans.

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Appendix A

Neurobehavioral Symptom Inventory Item Correlations (Spearman's Rho)

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1. Feeling dizzy	—																					
2. Loss of balance	.64*	—																				
3. Poor coordination, clumsy	.51*	.68*	—																			
4. Headaches	.38*	.35*	.35*	—																		
5. Nausea	.43*	.38*	.36*	.48*	—																	
6. Vision problems	.39*	.37*	.35*	.29*	.32*	—																
7. Sensitivity to light	.26*	.32*	.31*	.41*	.31*	.42*	—															
8. Hearing difficulty	.19*	.22*	.24*	.06	.15*	.20*	.11*	—														
9. Sensitivity to noise	.17*	.25*	.25*	.20*	.23*	.19*	.37*	.27*	—													
10. Numbness or tingling	.41*	.39*	.37*	.23*	.25*	.39*	.23*	.17*	.16*	—												
11. Change in taste or smell	.34*	.37*	.38*	.19*	.25*	.28*	.29*	.15*	.31*	.40*	—											
12. Change in appetite	.41*	.40*	.44*	.32*	.40*	.28*	.26*	.19*	.31*	.37*	.41*	—										
13. Poor concentration	.36*	.35*	.43*	.28*	.25*	.27*	.25*	.27*	.33*	.34*	.31*	.47*	—									
14. Forgetfulnes	.36*	.37*	.42*	.27*	.23*	.25*	.21*	.34*	.27*	.34*	.32*	.42*	.63*	—								
15. Difficulty making decisions	.39*	.37*	.47*	.23*	.27*	.28*	.25*	.18*	.36*	.38*	.43*	.46*	.60*	.55*	—							
16. Slowed thinking	.39*	.37*	.48*	.20*	.22*	.25*	.20*	.23*	.26*	.39*	.30*	.45*	.65*	.56*	.69*	—						
17. Fatigue	.42*	.39*	.41*	.32*	.31*	.27*	.28*	.19*	.25*	.44*	.39*	.49*	.55*	.49*	.47*	.56*	—					
18. Difficulty falling asleep	.28*	.32*	.34*	.34*	.31*	.22*	.30*	.19*	.32*	.33*	.34*	.42*	.38*	.36*	.32*	.31*	.41*	—				
19. Feeling anxious or tense	.28*	.29*	.28*	.29*	.24*	.18*	.32*	.19*	.42*	.34*	.28*	.38*	.53*	.42*	.48*	.45*	.49*	.53*	—			
20. Feelling depressed or sad	.32*	.28*	.36*	.21*	.30*	.18*	.21*	.15*	.31*	.28*	.28*	.46*	.44*	.40*	.42*	.43*	.49*	.47*	.53*	—		
21. Irritability, easily annoyed	.26*	.28*	.33*	.25*	.28*	.19*	.20*	.25*	.35*	.27*	.24*	.40*	.48*	.42*	.40*	.43*	.41*	.47*	.60*	.59*	—	
22. Poor frustration tolerance	.27*	.28*	.36*	.22*	.29*	.22*	.21*	.18*	.36*	.28*	.20*	.38*	.54*	.44*	.44*	.48*	.49*	.43*	.57*	.67*	.74*	—

* $p < .01$.

(Appendixes continue)

Appendix B

Neurobehavioral Symptom Inventory Residuals (After Controlling for Posttraumatic Stree) Interitem Correlations (Spearman's Rho)

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1. Feeling dizzy	—																					
2. Loss of balance	.60**	—																				
3. Poor coordination, clumsy	.46**	.63**	—																			
4. Headaches	.31**	.27**	.28**	—																		
5. Nausea	.34**	.32**	.28**	.43**	—																	
6. Vision problems	.34**	.33**	.29**	.23**	.26**	—																
7. Sensitivity to light	.17**	.25**	.24**	.36**	.25**	.38**	—															
8. Hearing difficulty	.12*	.14*	.16**	0	0.09	.16**	.04	—														
9. Sensitivity to noise	.04	.13*	.1	.1	.12*	.11*	.26**	.17**	—													
10. Numbness or tingling	.34**	.33**	.30**	.14*	.15**	.33**	.15*	.11*	.03	—												
11. Change in taste or smell	.24**	.28**	.29**	.08	.16**	.24**	.22**	.09	.18**	.33**	—											
12. Change in appetite	.27**	.27**	.31**	.19**	.30**	.21**	.15**	.09	.11*	.28**	.31**	—										
13. Poor concentration	.26**	.25**	.32**	.19**	.11*	.20**	.13*	.18**	.11*	.22**	.18**	.28**	—									
14. Forgetfulnes	.27**	.28**	.30**	.17**	.11*	.19**	0.1	.26**	.05	.24**	.18**	.25**	.57**	—								
15. Difficulty making decisions	.30**	.28**	.37**	.12*	.14*	.24**	.14*	.09	.18**	.26**	.29**	.30**	.46**	.43**	—							
16. Slowed thinking	.29**	.30**	.42**	.07	.11*	.19**	.07	.16**	0.06	.28**	.17**	.27**	.54**	.43**	.59**	—						
17. Fatigue	.29**	.26**	.29**	.20**	.17**	.17**	.16**	.08	.06	.34**	.23**	.33**	.39**	.34**	.30**	.41**	—					
18. Difficulty falling asleep	.1	.15**	.16**	.21**	.14*	.1	.18**	.02	.02	.18**	.15**	.18**	.09	.05	.02	.01	.18**	—				
19. Feeling anxious or tense	.09	.12*	.07	.16**	.05	.04	.17**	.04	.15**	.16**	.05	.09	.29**	.17**	.26**	.20**	.28**	.18**	—			
20. Feelling depressed or sad	.13*	.07	.18**	.04	.13*	.04	.07	−.03	.02	.11*	.08	.21**	.12*	.12*	.12*	.15**	.23**	.11*	.18**	—		
21. Irritability, easily annoyed	.06	.1	.14*	.11*	.09	.06	0	.15**	.07	.09	0	.11*	.17**	.16**	.12*	.17**	.14**	.13*	.29**	.28**	—	
22. Poor frustration tolerance	.11*	.16**	.22**	.1	.1	.14	.07	.07	.11	0.1	−.01	.11*	.32**	.22**	.22**	.24**	.29**	.08	.31**	.42**	.57**	—

* $p < .05$. ** $p < .01$.

Received May 20, 2009
Revision received June 2, 2009
Accepted June 3, 2009 ■